Electrical Power Engineering (2)

Code: EP2207

Lecture: 4 **Tutorial: 4** **Total: 8**

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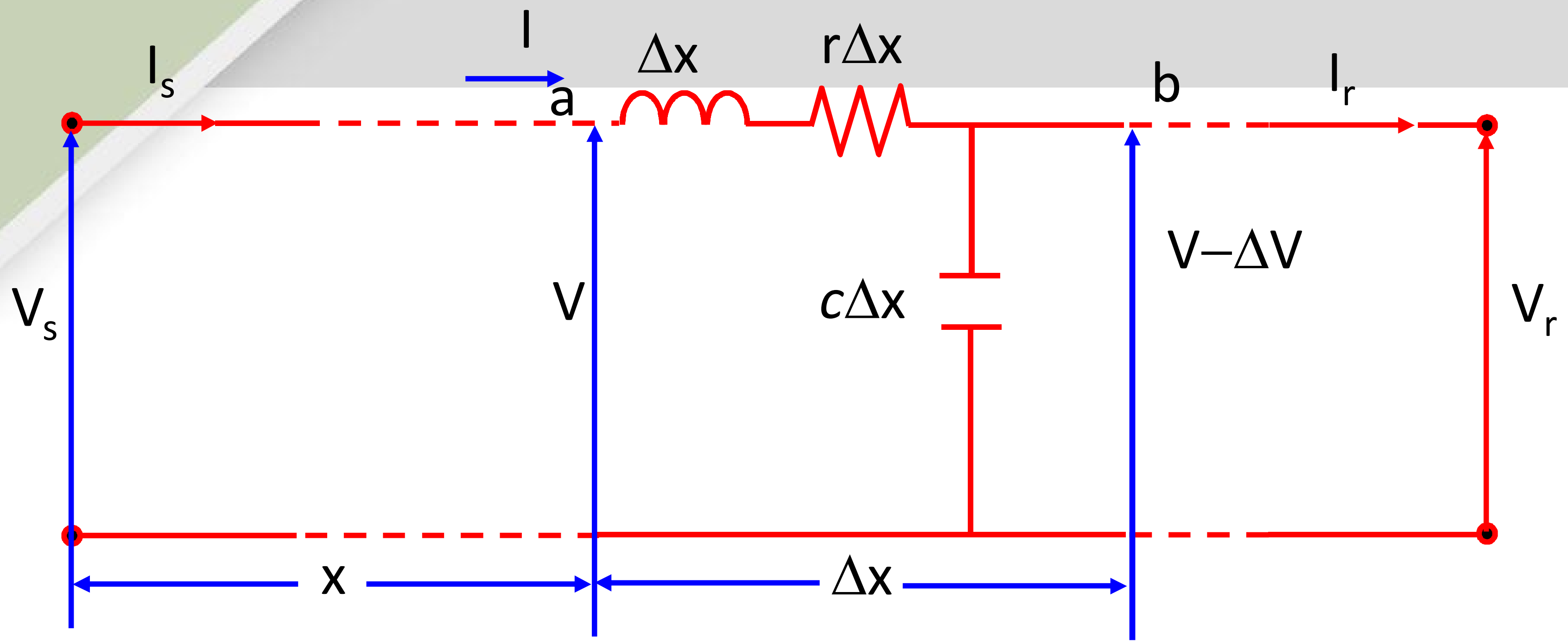
Performance of long transmission lines



r: is the resistance per unit length of the line

l: is inductance per unit length of the line

z: is impedance per unit length of the line

c: is capacitance per unit length of the line

y: is admittance per unit length of the line

Performance of long transmission lines

θ: is the propagation constant معامل الإنتشار

$$\boxed{\theta = \sqrt{zy}} \qquad \theta = \alpha + j\,\beta$$

α: is the attenuation constant معامل التوهين

β: is the phase constant

Z_o: is the characteristic impedance of the line

$$\boxed{Z_o = \sqrt{\frac{z}{y}}}$$

Performance of long transmission lines

$$V_s = \cosh(\theta) V_r + Z \frac{\sinh(\theta)}{\theta} I_r$$

$$I_s = Y \frac{sinh(\theta)}{\theta} V_r + cosh(\theta) I_r$$

A=D = cosh (θ)

$$B = Z \frac{sinh(\theta)}{\theta}$$

$$C = Y \frac{sinh(\theta)}{\theta}$$

Equivalent Π and T of long TL

Nominal T representation

$$\boxed{A = D = 1 + \frac{Z'Y'}{2} = \cosh(\theta)}$$

$$\boxed{B = Z'\left(1 + \frac{Z'Y'}{4}\right) = Z\frac{sinh(\theta)}{\theta}}$$

$$\boxed{C = Y' = Y\frac{sinh(\theta)}{\theta}}$$

Equivalent Π and T of long TL

Nominal T representation

$$\frac{Z'Y'}{2} = \cosh(\theta) - 1$$

$$\frac{Z'}{2}\left(Y\frac{\sinh(\theta)}{\theta}\right) = \cosh(\theta) - 1$$

$$\frac{Z'}{2} = \left(\frac{\cosh(\theta) - 1}{\sinh(\theta)}\right)\frac{\theta}{Y}$$

$$\mathrm{A} = \mathrm{D} = 1 + \frac{Z'Y'}{2} = \cosh(\theta)$$

$$\boxed{Y' = Y\frac{\sinh(\theta)}{\theta}}$$

$$\frac{Z'}{2} = \frac{\theta}{Y}\left(\frac{\tanh(\frac{\theta}{2})}{\frac{\theta}{2}}\right)\frac{\theta}{2} = \frac{\theta^2}{2Y}\left(\frac{\tanh(\frac{\theta}{2})}{\frac{\theta}{2}}\right)$$

$$\boxed{Z' = Z\left(\frac{\tanh(\frac{\theta}{2})}{\frac{\theta}{2}}\right)}$$

Equivalent Π and T of long TL

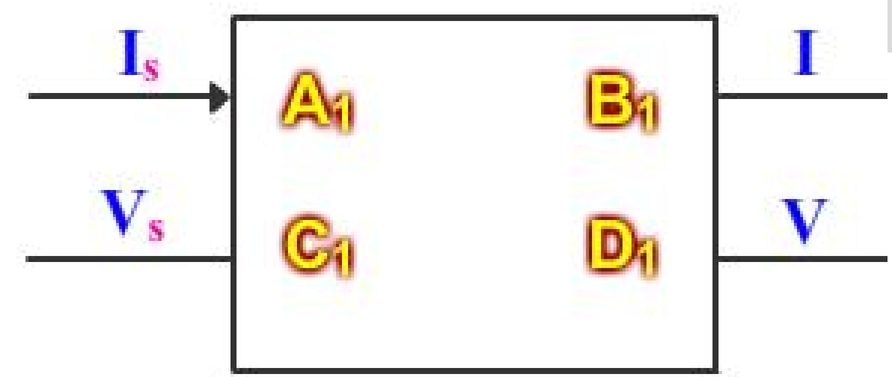
Nominal Π representation

$$\mathrm{A} = \mathrm{D} = 1 + \frac{\mathrm{Z}'\mathrm{Y}'}{2} = cosh(\theta)$$

$$\mathrm{B} = \mathrm{Z}' = \mathrm{Z}\frac{sinh(\theta)}{\theta}$$

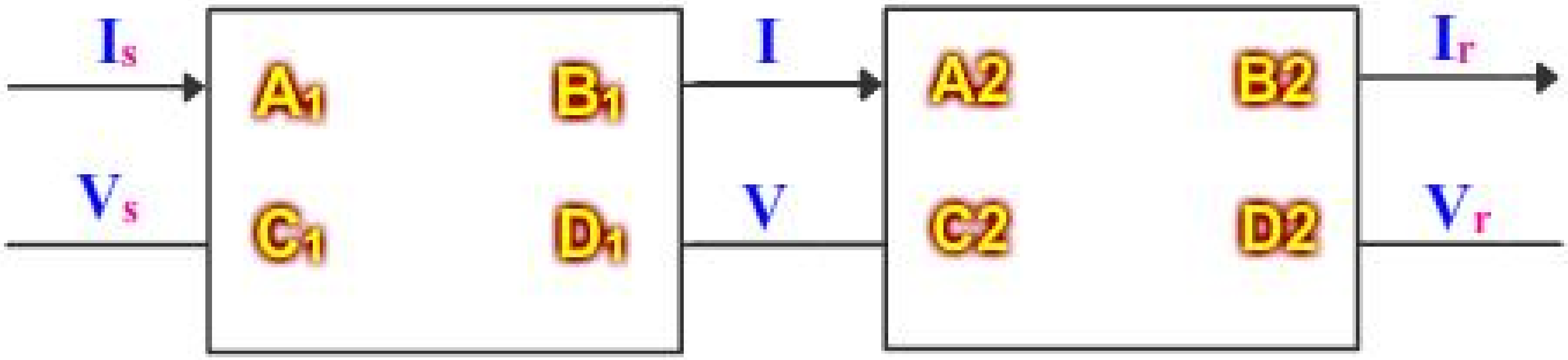
$$\mathrm{Y}' = \mathrm{Y}\left(\frac{\tanh\left(\frac{\theta}{2}\right)}{\frac{\theta}{2}}\right)$$

General Constants of cascaded TL



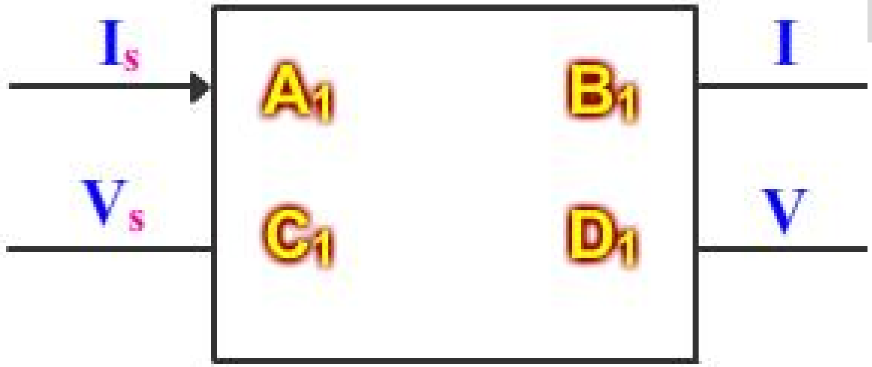
$$V_s = A_1 V + B_1 I$$

$$I_s = C_1 V + D_1 I$$



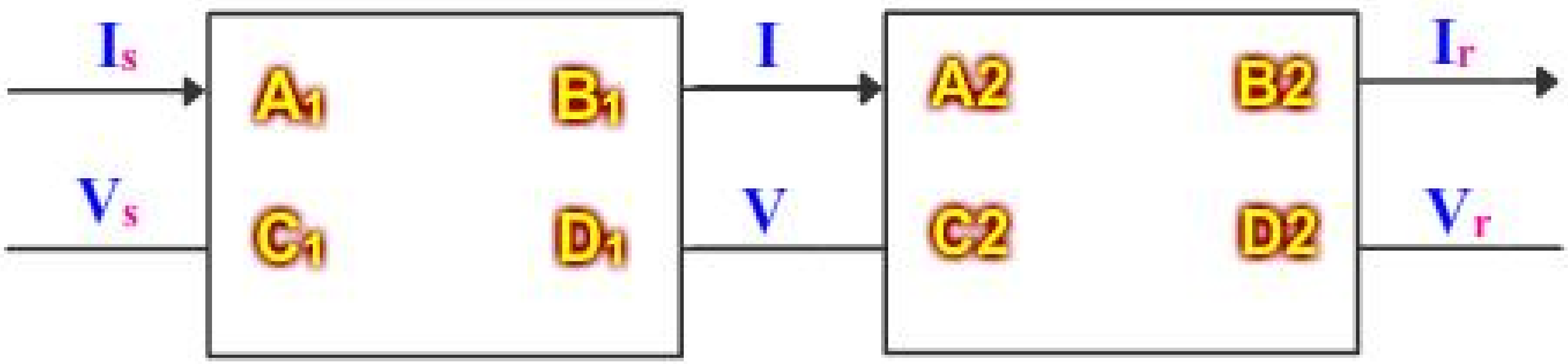
$$V = A_2 V_r + B_2 I_r \qquad I = C_2 V_r + D_2 I_r$$

General Constants of cascaded TL



$$V_s = A_1 V + B_1 I$$

$$I_s = C_1 V + D_1 I$$



$$V = A_2 V_r + B_2 I_r \qquad I = C_2 V_r + D_2 I_r$$

General Constants of cascaded TL

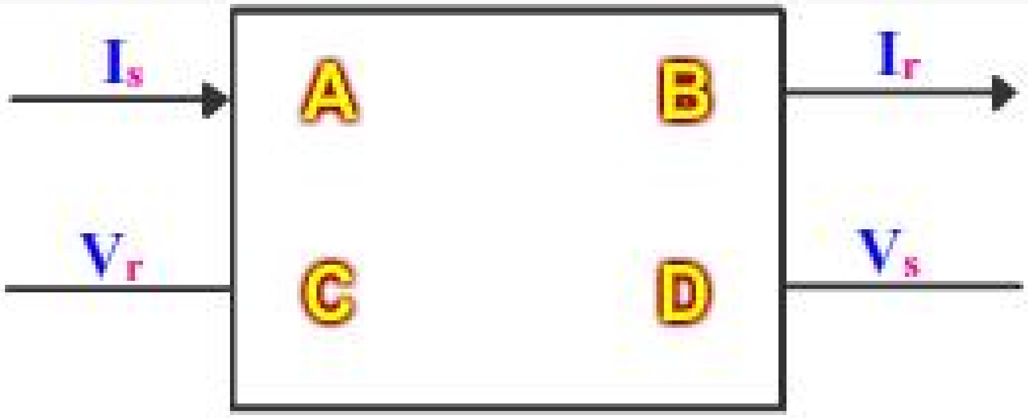
$$\begin{bmatrix} V \\ I \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_r \\ I_r \end{bmatrix}$$

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V \\ I \end{bmatrix}$$

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_r \\ I_r \end{bmatrix}$$

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} A_1A_2 + B_1C_2 & A_1B_2 + B_1D_2 \\ C_1A_2 + D_1C_2 & C_1B_2 + D_1D_2 \end{bmatrix} \begin{bmatrix} V_r \\ I_r \end{bmatrix}$$

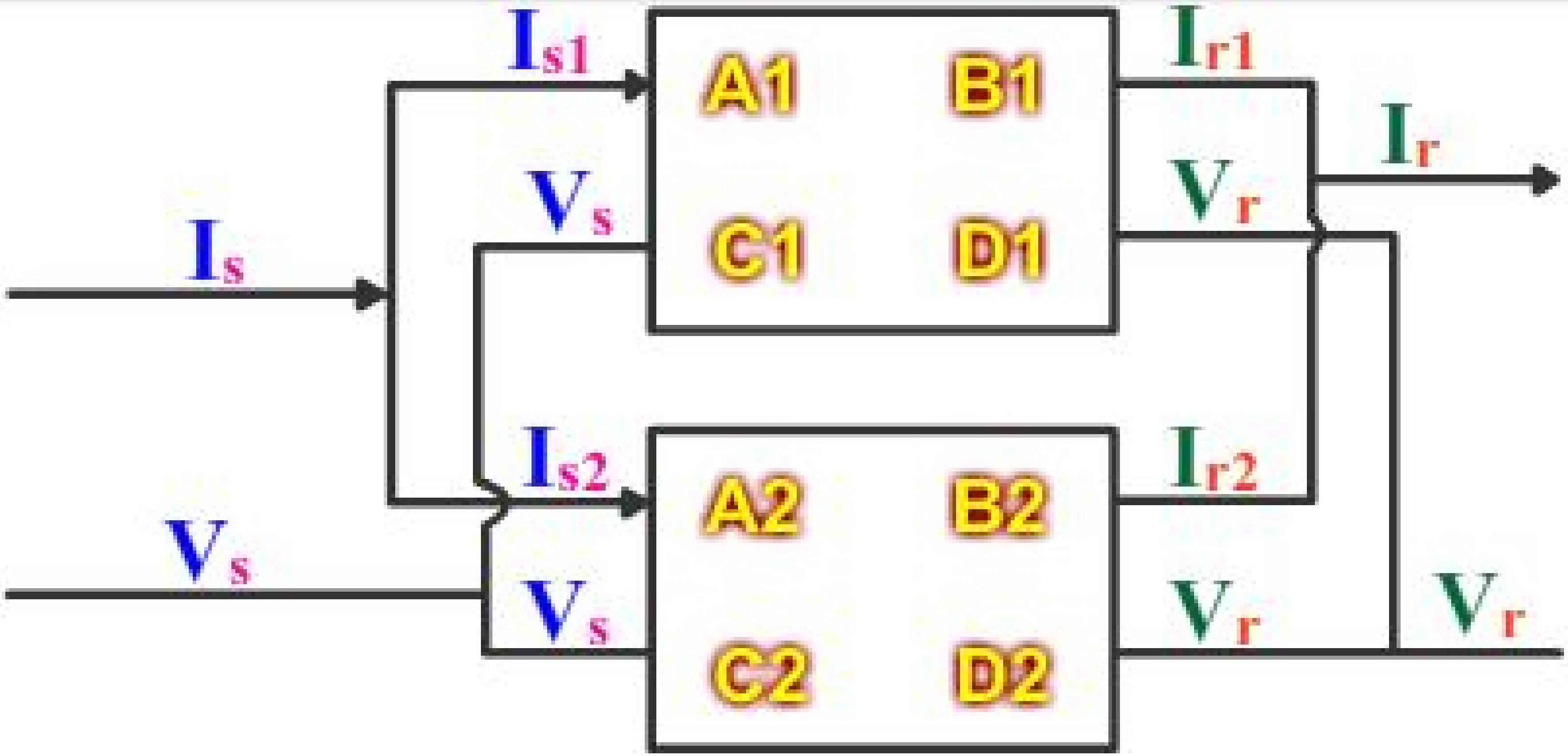
General Constants of cascaded TL



$A = A_1A_2 + B_1C_2$ $\quad$ $B = A_1B_2 + B_1D_2$

$C = C_1A_2 + D_1C_2$ $\quad$ $D = C_1B_2 + D_1D_2$

General Constants of Parallel TL



$$A_1V_r+B_1I_{r1}= A_2V_r+B_2I_{r2}$$

$$I_{r2}= I_r - I_{r1}$$

General Constants of Parallel TL

$$A_1V_r+B_1I_{r1}= A_2V_r+B_2I_{r2}$$

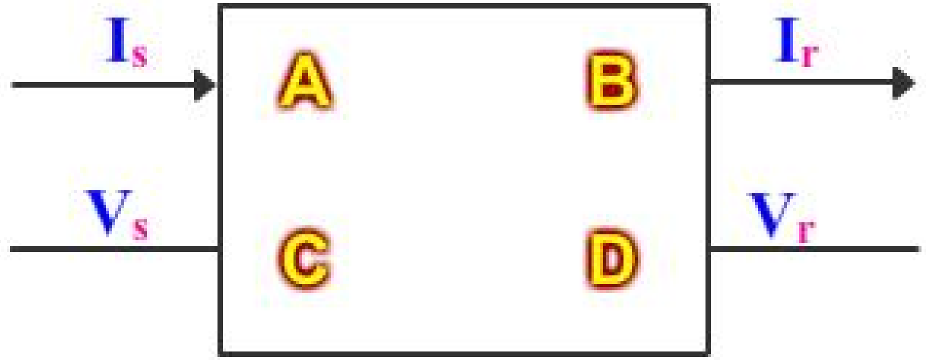
$$I_{r2}= I_r - I_{r1}$$

Thus,

$$V_S = \frac{A_1B_2+B_1A_2}{B_1+B_2} V_r + \frac{B_1B_2}{B_1+B_2} I_r$$

$$I_s = C_1+C_2+ \frac{(A_2-A_1)(D_1-D_2)}{B_1+B_2} V_r + \frac{B_1D_2+B_2D_1}{B_1+B_2} I_r$$

General Constants of Parallel TL



$$A = \frac{A_1B_2 + B_1A_2}{B_1 + B_2}$$

$$B = \frac{B_1B_2}{B_1 + B_2}$$

$$C = C_1 + C_2 + \frac{(A_2 - A_1)(D_1 - D_2)}{B_1 + B_2}$$

$$D = \frac{B_1D_2 + B_2D_1}{B_1 + B_2}$$